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FUTURE ENERGY CHALLENGES, OPPORTUNITIES AND SMART-GRIDS

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ABSTRACT

In this paper the author has described global energy trends, evolution of smart gridsand their technical challenges and an energy efficient future. The update of Smart Grid requires the complex integration of communications and information system with traditional power grids and networks. The overall objective is to help in identifying the future energy challenges and their solutions with reliability and sustainability. Energy security is essential for economic prosperity. This requires multidisciplinary approach by the production of energy with conventional sources as well as non-conventional sources along with integration of same with the power grids to meet out the energy challenges of 21^{st} century.

Keywords: Energy trends, Smart Grids, Non-conventional/Renewable source of energy, Conventional/Non-Renewable source of energy, Communication and Information.

I. INTRODUCTION

In today's scenario electrical energy is the backbone of all the economics and it supports every aspect of social and cultural life throughout the world. For this efficient generation, transmission & distribution is a fundamental requirement with essential energy resources. The global demand of energy is steadily rising because of rapid population growth and generally longer lives. The demand of electricity is growing at annual three percent faster than the two percent annual increase. The process of urbanization and development of smart cities is continuing to accelerate the energy crisis which leads to Future Energy Challenges.

On the other hand fossil energy sources are getting scare while non-convectional energy is more expensive therefore evolution of the smart grid has now become critical to the development of sustainable energy provision. Communication and information technologies are vital links to do the integration of consumers, suppliers and distributors with the smart grid.

II. FUTURE ENERGY CHALLENGES

A. Energy Prices

Energy prices and high associated volatility, have become the most critical uncertainty.

B. Carbon capture, utilisation and storage (CCUS)

Carbon capture, utilisation and storage (CCUS), is perceived with rapidly diminishing impact, continuing the clear trend of the past three years and reinforcing the reality check needed around our ability to deliver on climate objectives by 2050.

C. Energy efficiency

Energy efficiency, remains stable in it's positioning as an action priority for the fifth successive year and continues to present an immediate opportunity, but will only be realised with a longer-term approach to financing.

D. Energy Security

Energy Security, The effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of energy providers to meet current and future demand.

E. Energy Equity

Energy Equity, Accessibility and Affordability of energy supply across the population.

F. Environmental Sustainability

Environmental Sustainability Encompasses the achievement of supply and demand-side energy efficiencies and the development of energy supply from renewable and other low-carbon sources.

III. GLOBAL ENERGY TRENDS

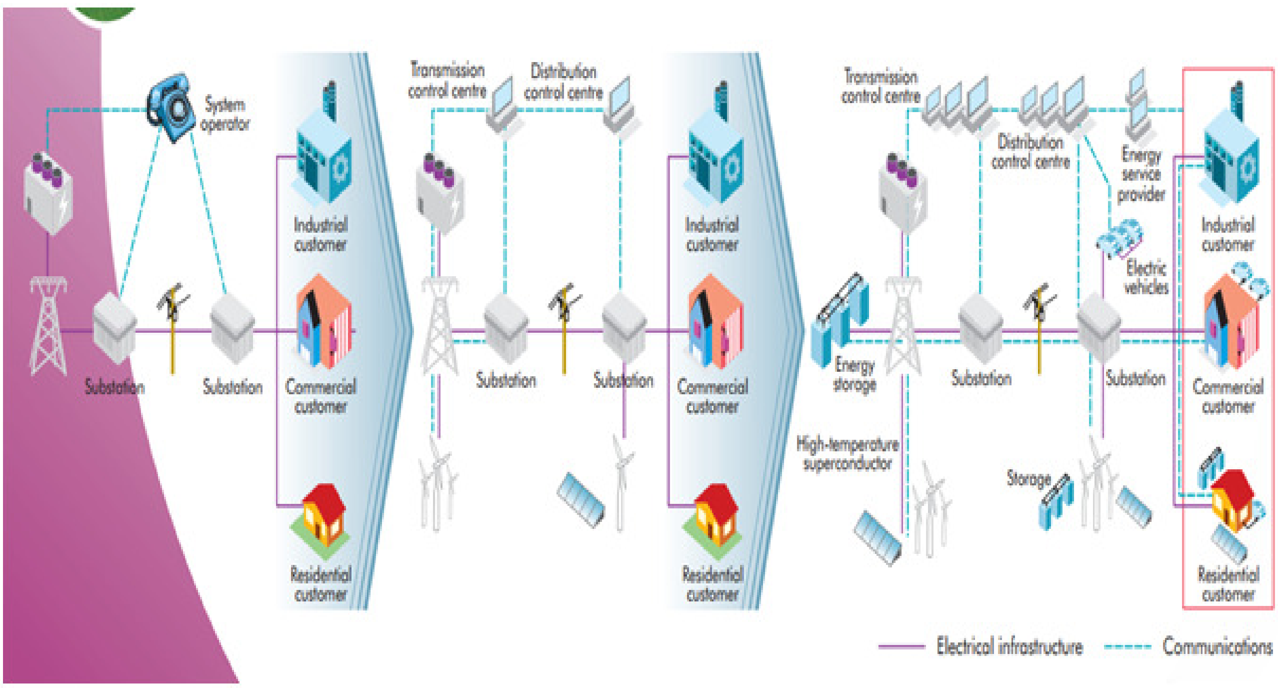
- Global population and economic growth can be decoupled from energy demand, even for oil.
- Solar, hydropower and onshore wind are presently forging ahead, while development is mixed for other clean energy supply.
- Emerging economies have stepped up their ambitions and become leaders in deploying low-carbon energy technologies.
- Continued increase in coal use counteracts emissions reduction from recent progress in the deployment of renewables, underlining the need to improve coal plant efficiency and scale up carbon capture and storage (CCS).
- Fossil fuel use decreases by 2050, but its share of primary energy supply remains above 40%, reflecting its particularly important role for use in industry, transport and electricity generation.
- Energy efficiency makes the largest contribution to global emissions reduction, but needs to be combined with other technologies to meet long term targets.

IV. FUTURE ENERGY TRENDS AND VISIONS

- Sustainable Cities: Realizing resource efficient urbanization at scale.

- Carbon Capture, Utilization and Storage (CCUS): Overcoming barriers to achieving scale, innovative solutions to make projects viable (enhanced oil recovery, CO2-to-plastic, CO2 -to-algae/bio fuels).
- Renewable Energy: Maintaining traction to achieving scale.
- Bio Fuels: Overcoming barriers to realising potential.
- SMART GRID: Decentralised solutions and business models taken to scale.
- Electricity Storage: Cheaper batteries, ‘power to gas’ storage (of excess generation from renewables) and scalability.
- Nuclear: Future of nuclear power with safety, post-Fukushima accident on 11th March 2011.
- Hydropower: Overcoming barriers to realising potential.
- Unconventional Fossil Fuels: Shale gas, oil shale, potentially other unconventional realising potential, altering global oil and gas market dynamics.
- Hydrogen Economy: Advancing to an achievable incremental vision.
- Energy Efficiency: Overcoming barriers to implementation and achieving its potential as well as capable of meeting increased consumer demand without adding infrastructure.
- Future Mobility/Electricity Vehicles: Innovative mobility concepts, new transportation modes and fuel sources, including electric vehicles, natural gas vehicles realising potential creating new opportunities in market by means of its ability to capitalise on plug and play innovation wherever and whenever appropriate.
- Quality focused: Capable of delivering the power-free of sags, spikes, disturbances and interruptions.
- Resilient: Increasingly resistant to attack and natural disasters as it becomes more decentralised and reinforced with smart grid security protocols.
- Green: Slowing the advance of global climate change and offering a genuine path towards significant environmental improvement.

The “smartening of the electricity system is an evolutionary process, not a one-time event”



“Smarter Electricity Systems & Future Energy Trends”

V. SMART GRIDS

"Current trends in energy supply and use are patently unsustainable – economically, environmentally and socially. Without decisive action, increased fossil fuel demand will heighten concerns over the security of supplies and energy related emissions of carbon dioxide (CO_2) will more than double by 2050"

We can and must change our current path, but this will take an energy revolution and low-carbon energy technologies will have a crucial role to play. Energy efficiency, many types of renewable energy, carbon capture and storage, nuclear power and new transport technologies will all require widespread deployment if we are to reach our greenhouse-gas emission goals. Every major country and sector of the economy must be involved.

- Smart Grid is one of the major trends and markets which involve the whole energy conversion chain from generation to consumer. The power flow will change from a unidirectional power flow to a bidirectional power flow.
- The Smart Grid is the concept of modernizing electrical grid.
- The Smart Grid is integrating the electrical and information technology in between any point of generation and any point of consumption.
- Smart grids – the infrastructure that enables the delivery of power from generation sources to end-uses to be monitored and managed in real time.
- Smart grids are required to enable the use of a range of low carbon technologies, such as variable renewable resources and electric vehicles, and to address current concerns with the electricity system infrastructure, such as meeting peak demand with an ageing infrastructure. Unlike most other low carbon energy technologies.
- Smart grids must be deployed in both existing systems (which in some cases are over 40 years old) as well as within totally new systems. Smart grid technologies must also be installed with minimum disruption to the daily operation of the electricity system.

A. Why is SMART GRID still a Question mark?

"Smart Grid" Is one of the major trends and markets which involve the whole energy conversion chain from generation to consumer. The power flow will change from a unidirectional power flow to a bidirectional power flow.

The smart grid is the concept of modernizing electrical grids. The smart grid is integrating the electrical systems and information technologies in between any point of generation and any point of consumption.

"A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience and stability."

Rationale for smart grid technology

The world's electricity systems face a number of challenges:

- Including ageing infrastructure,
- Continued growth in demand,
- The integration of increasing numbers of variable renewable energy sources and electric vehicles,
- Need to improve the security of supply and the need to lower carbon emissions.

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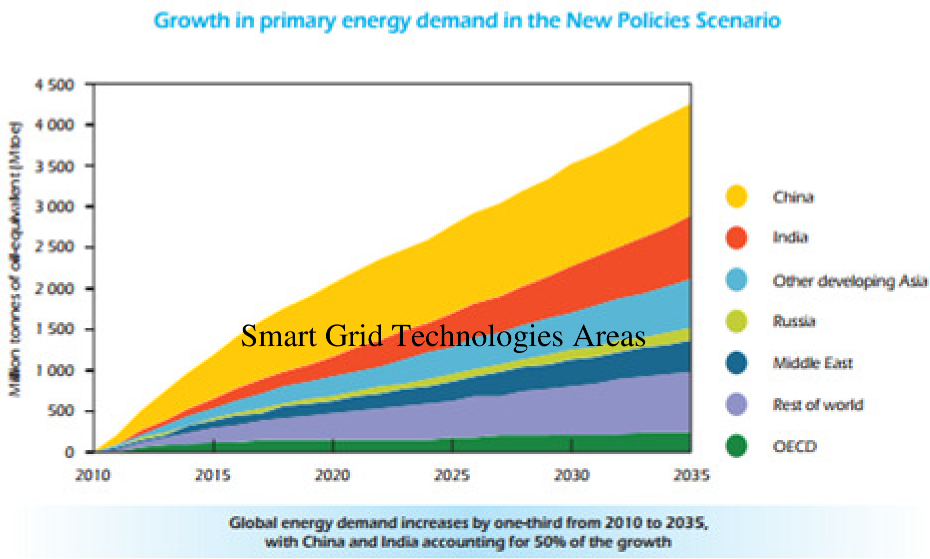
"Smart grid technologies offer ways not just to meet these challenges but also to develop a cleaner energy supply that is more energy efficient, more affordable and more sustainable. "

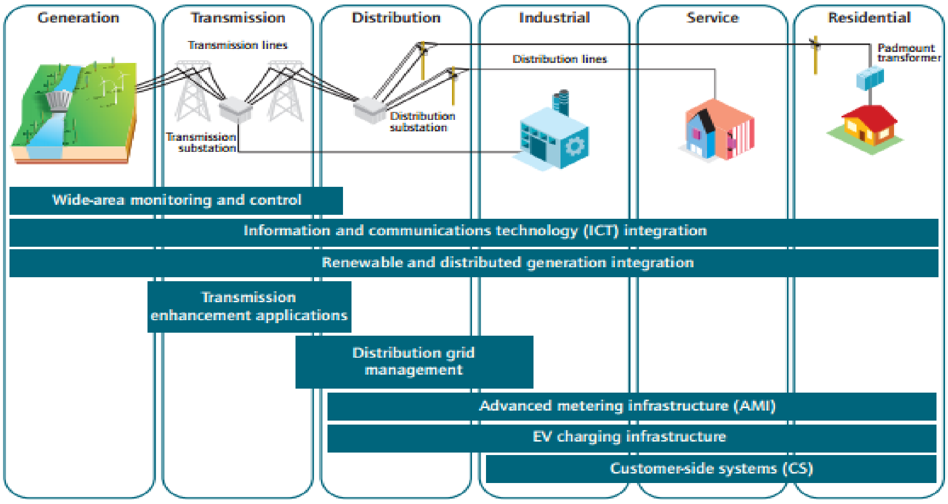


Smart Grid Technologies Areas

Technology Areas, Hardware and Systems and Software's

- Technology Area: Wide-area monitoring and control
- Hardware: Phasor measurement units (PMU) and other sensor equipment
- System and Software: Supervisory control and data acquisition (SCADA), wide-area monitoring systems (WAMS), wide-area adaptive protection, control and automation (WAAPCA), wide area situational awareness (WASA)
- Technology Area: Information and Communication technology Integration
- Hardware: Communication equipment (Power line carrier, WIMAX, LTE, RF mesh network, cellular), routers, relays, switches, gateway, computers (servers)
- System and Software: Enterprise resource planning software (ERP), customer information system (CIS)
- Technology Area: Renewable and distributed generation integration
- Hardware: Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology
- System and Software: Energy management system (EMS), Distribution management system (DMS), SCADA, Geographic Information system (GIS)
- Technology Area: Transmission Enhancement
- Hardware: Superconductors, FACTS, HVDC
- System and Software: Network stability analysis, automatic recovery systems
- Technology Area: Distribution Grid Management
- Hardware: Automated re-closers, switches and capacitors, remote controlled distributed generation and storage, transformer sensors, wire and cable sensors
- System and Software: Geographic information system (GIS), Distribution management system (DMS), outage management system (OMS), Workforce management system (WMS)
- Technology Area: Advanced metering Infrastructure
- Hardware: Smart meter, in-home displays, servers, relays

- System and Software: Meter data management system (MDMS)
- Technology Area: Electric Vehicle charging infrastructure
- Hardware: Charging infrastructure, batteries, inverters
- System and Software: Energy billing, smart grid-to-vehicle charging (G2V) and discharging vehicle-to-grid (V2G) methodologies
- Technology Area: Customer-side systems
- Hardware: Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostat
- System and Software: Energy dashboards, energy management systems, energy applications for smart phones and tablets



Source: Technology categories and descriptions adapted from NETL, 2010 and NIST, 2010.

B. Maturity levels and development trends of smart grid technologies

Technology Area	Maturity Level	Development Trend
Wide-area monitoring and control	Developing	Fast
Information and Communication technology Integration	Mature	Fast
Renewable and distributed generation integration	Developing	Fast
Transmission Enhancement	Mature	Moderate
Distribution Grid Management	Developing	Moderate
Advanced metering Infrastructure	Mature	Fast
Electric Vehicle charging infrastructure	Developing	Fast
Customer-side systems	Developing	Fast

Today researchers are doing brilliant theoretical work on the smart grids but are not aware of the problems and ground realities to create actual smart grids, as in many countries the existing grids and electrical networks are not up to the mark. Therefore with awareness of the challenges it is important to create first a moldel of smart grid. So it may provide deeper knowledge to meet the technical challenges and can help to learn more.

C. Smart Grid Technologies Challenges

"The Smart Grid is broad in its scope, so the potential standards landscape is also very large and complex. The fundamental issue is organization and prioritization to achieve an interoperable and secure Smart Grid".

D. Preparing for the Future: How Asset Management will evolve in the Age of the Smart Grid

1) The State of Asset Management in Utilities today: Electricity utilities have a variety of software tools available to manage their assets

- Asset/Work Management Systems
- GIS
- Planning Systems
- SCADA
- DMS
- Fixed Asset Accounting

2) The Advent of Smart Grid: The underlying business drivers for a smarter grid have forced utilities to recognize the need to manage distribution grids more effectively. Some of the most important factors include:

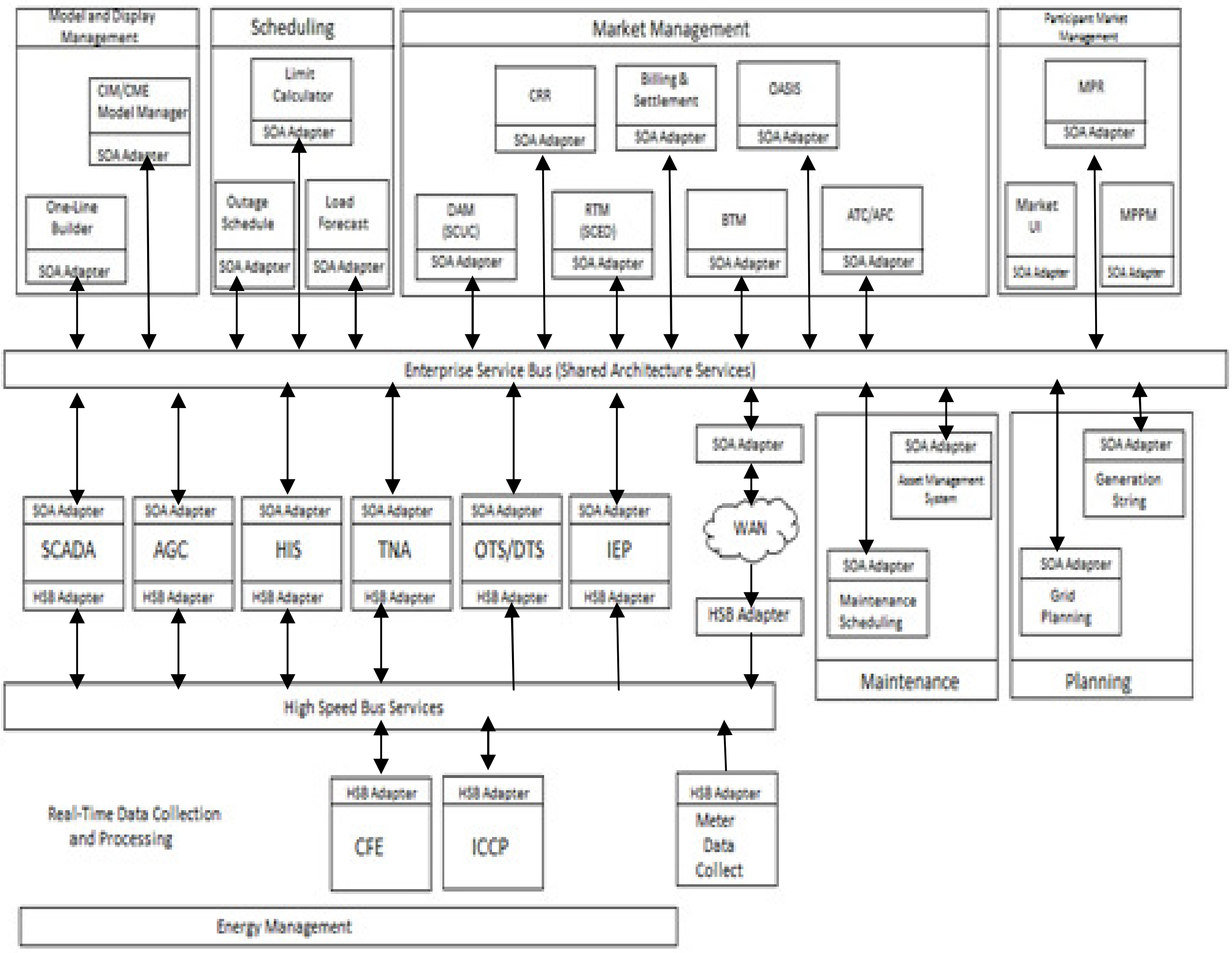
- Demand patterns are changing.
- Additional telemetry devices are being deployed on the distribution network.
- Generations becoming more distributed.
- Additional smart switches are being added to the distribution network.

3) Smart Asset (Information) Management

- Establishment of a 'single version of the truth'.
- Elimination of the use of special purpose databases for smart grid assets.
- Establishment of spatial databases to manage smart grid asset information.
- Establishment of a work flow management tool to support database updates.

<u>Key control technology functions in Distribution Networks</u>

- SCADA (supervision control and data acquisition)
- Load and generation forecasting
- Outage and work order management (OMS)
- Fault management
- Troubleshooting
- Planned outages
- Corrective action
- Demand response and load management
- Switching procedures
- Trouble call management
- Crew management
- Geospatial information systems (GIS)
- Customer information
- Asset management



AFC	Available Flow Gate Calculation	HIS	Historical Information System
AGC	Automatic Generation Control	IEP	Intelligent Event Processor
ATC	Available Transmission Capacity Calculation	ICCP	Inter Control-Center Communication Protocol
BTM	Bilateral Transmission Capacity	MPR	Market Participant Registration
CFE	Communications Front End (RTCS)	MPPM	Market Participant Prudential Management
CIM	Common Information Model	OASIS	Transmission Reservation
CME	CIM Market Extension	OTS	Operator Training Simulator
CRR	Congestion Revenue Right	RTM	Real-Time market
DAM	Day- Ahead Market	SCUC	Security-Constrained Unit Commitment
FEP	Front End Processor	TNA	Transmission Network Application

E. GIS- Application of Smart Grid Technology : An Energy-Efficient Future

“Geographic information systems (GIS) play an important role to help the utilities industry manage the smart grid for an energy-smart future. And that means there is a growing need for professionals with a solid foundation in GIS technology to monitor electrical distribution systems, analyse power usage and plan future load growth to meet the changing needs of communities.”

A modal network control system provides a service oriented architecture with standardised process, interface and communication specifications based on standards IEC 61968 and IEC 61970. These form the basis for integrating the network control system in the enterprise service environment of the power supply company.

Service - oriented architecture for smart-grid application has been shown below:
GIS Makes the Smart Grid Smart by:

Data Management	**Utilities already rely on GIS to manage assets and outages and map the location of overhead and underground circuits.**
Planning and Analysis	To see whether a smart grid deployment is effective, utilities use GIS to analyse marketing campaigns and study customer behaviour patterns along with demand response.
Workforce Automation	A smart grid relies on accurate data. Mobile GIS is the surest way to move data quickly to and from the field and the office. The productivity of a smart grid implementation can be increased by using GIS to schedule and dispatch utility crews
Situational Awareness	Utilities bring it all together with GIS to view and track smart grid deployment and operation. Through GIS-based graphic outputs and Web-based reporting, they are able to quickly monitor and demonstrate how the organization is progressing on smart grid activities. GIS provides a Web-based dashboard that shows the status of any project, alerts staff to variances in the schedule, monitors investments, and locates new work orders

CONCLUSION

To meet the future energy challenges the following system pulls are to be taken seriously.

1. Application of power electronics into Generic Systems.
2. Efficient Energy Strategy.
3. Smart grid standards, protocols, reliability, power system automation and security.
4. Smart grid markets and mechanism.
5. Data management and forecasting, wide area monitoring and control, smart metering (SM) and automatic metering infrastructure (AMI).
6. Big data/data analysis of smart grid applications to power engineering.
7. Smart grid networking and communication implementations.
8. Smart Grid Issues such as planning, operation and control of smart grids.

The Future Energy challenges and evolution of smart grid technologies have to be taken sincerely and seriously in order to solve from all the directions to make energy sustainable and reliable for every human being on the earth.

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